

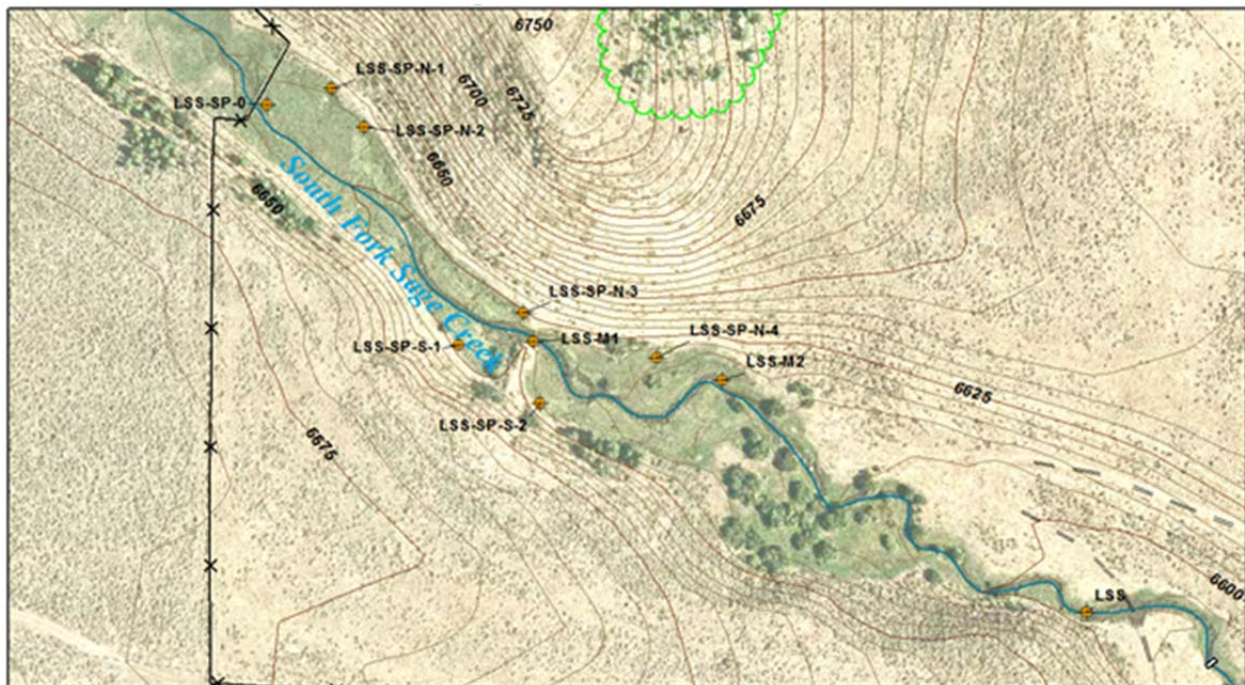
Appendix A
Calculation of Selenium Load Removal by Treatment and Effect on Downstream Concentrations

I. Estimate of Selenium Load Removal by Treatment

Table 1 shows a summary of selenium concentration and water flow data from 2013. For the calculations of load removal, data from fall 2013 (low conditions) are used. Table 2 shows the load removal estimate for the 2014 system which is projected to treat 125 gpm each from South Fork Sage Creek Springs and Hoopes Spring. Tables 3 and 4 show selenium load removal estimates for a system treating 1,000 and 2,000 gpm, respectively. A division of flow rates from each spring is assumed, however, these may be different in the actual study depending on how flow development occurs at the springs in 2015.

Key Assumptions

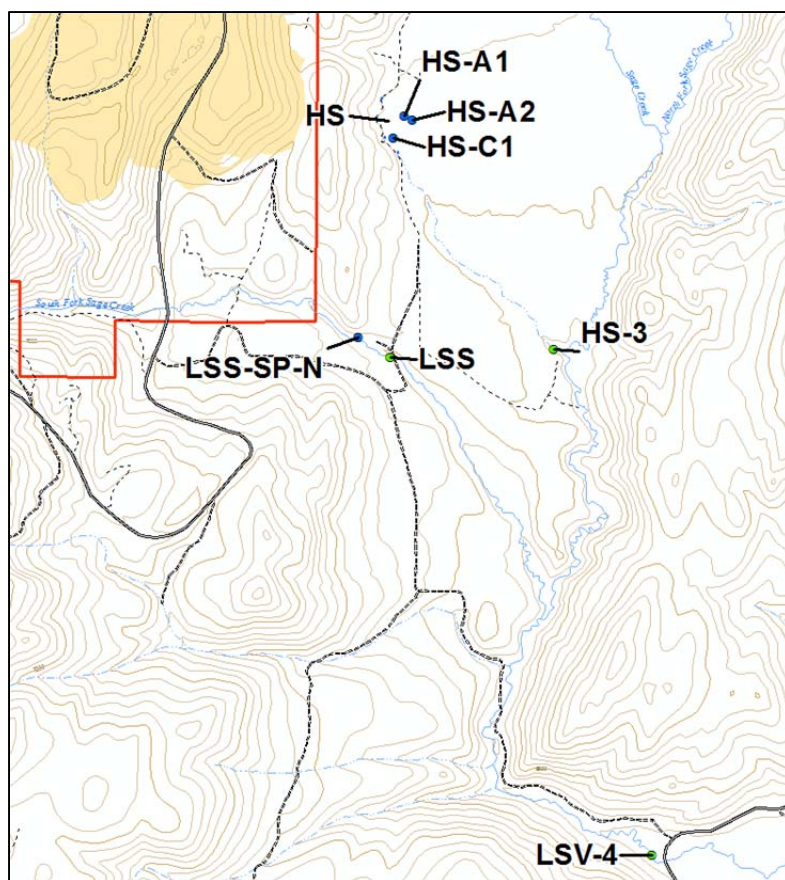
Selenium concentrations in fall 2013 were 0.0777 mg/L at location HS-3 and 0.0194 mg/L at location LSS (downstream of Hoopes Spring and South Fork Sage Creek Spring, respectively). Total flow from the springs was 2,300 gpm for South Fork Sage and 3,300 gpm for Hoopes. Flow removed from the South Fork Sage Creek Springs will be pumped to the treatment building located near Hoopes. Treated water will be discharged to surface upstream of HS-3. The treatment efficiency is assumed to be 100% (the AbMet study showed selenium removal in the range of 99.6 to >99.9%). Concentrations in surface water vary during the year primarily due to runoff conditions. The calculation, which uses low-flow data, is therefore expected to be conservative.



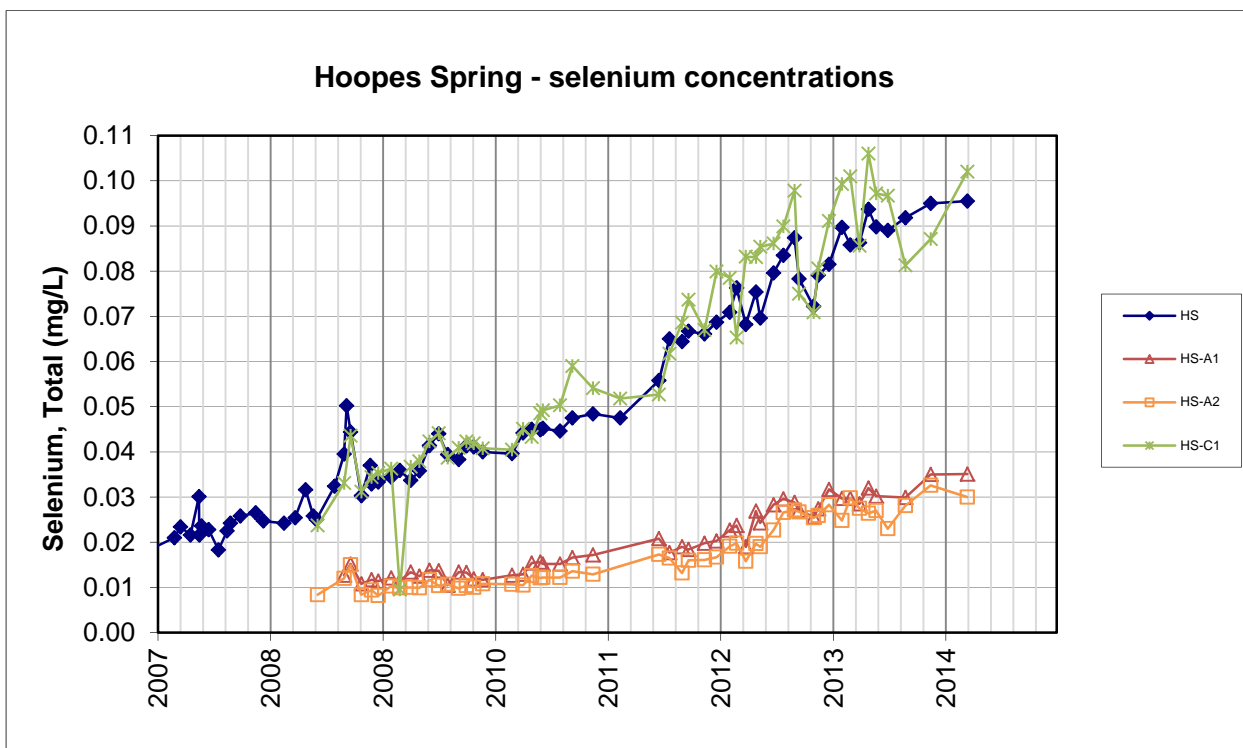
South Fork Sage Creek Springs

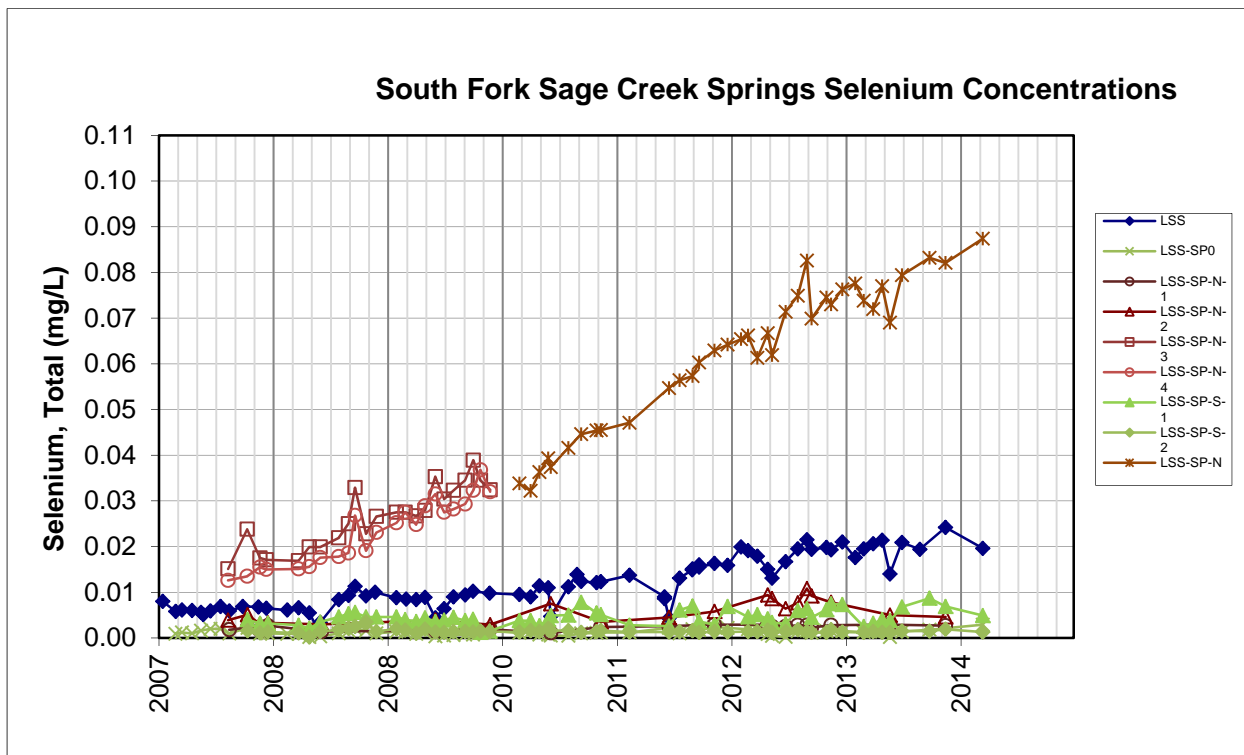
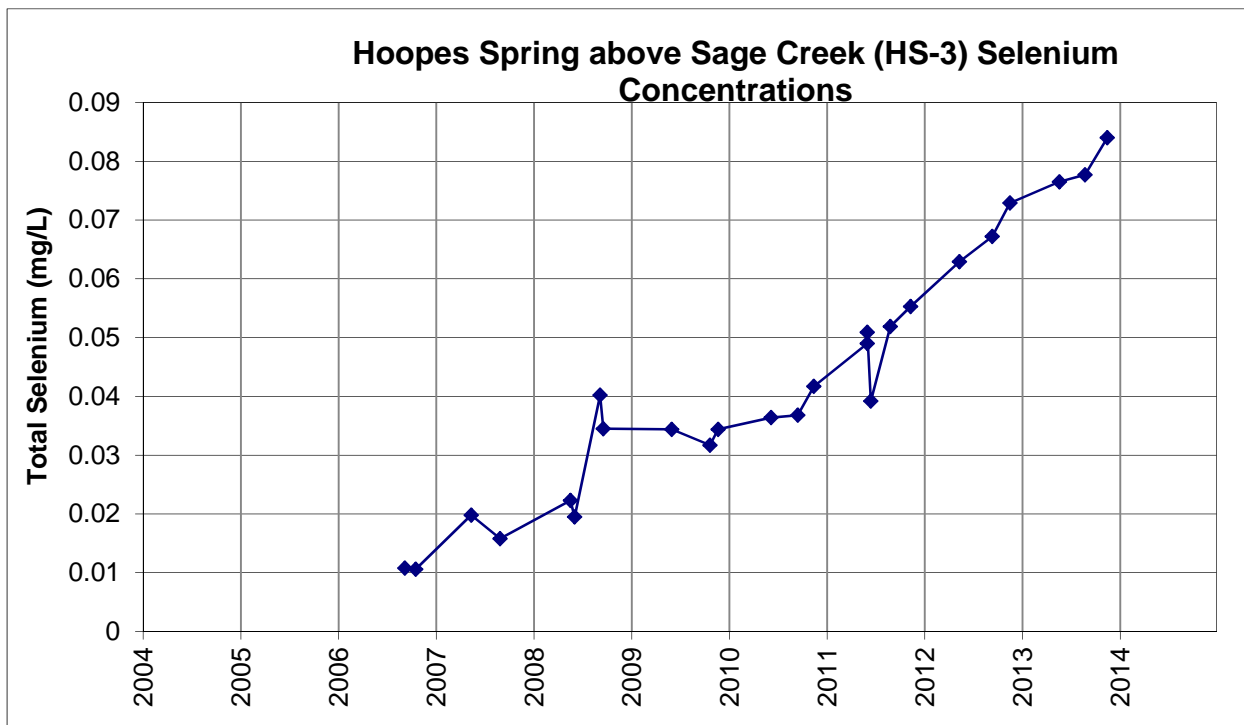


Hoopes Spring



Hoopes and South Fork Sage Creek Sample Locations, and Downstream Sage Creek Location LSV-4





Bookend Assumption #1: The selenium load at each spring complex comes entirely from a subgroup of individual springs with the same relatively high selenium concentration.

At location HS-3 (downstream of Hoopes Spring) the measured selenium concentration was 0.0777 mg/L and the measured flow was 3,276 gpm, yielding a mass flux of selenium on 3.06 lbs/day (Table 2). At Hoopes Spring it is assumed that the entire load comes from a group of individual springs that had selenium concentrations of 0.0918 mg/L in 2013.

At location LSS (downstream of South Fork Sage Creek Springs) the measured selenium concentration was 0.0194 mg/L and the measured flow was 2,300 gpm, yielding a mass flux of selenium on 0.536 lbs/day (Table 2). At South Fork Sage Creek it is assumed that the entire load comes from a group of springs that had selenium concentrations of 0.0832 mg/L.

Tables 2, 3 and 4 present calculations for the mass of selenium removed by three treatment scenarios:

1. Pilot System, Step 1 (250gpm): Initial startup of the pilot system. Influent will consist of 125 gpm, high concentration spring water from LSS-SP-N, with an additional 125 gpm from high concentration Hoopes spring water (HS).
2. Pilot System, Step 2 (1,000 gpm): Option 1. Influent will consist of 500 gpm, high concentration spring water from LSS-SP-N, with an additional 500 gpm from high concentration Hoopes spring water (HS).
3. Pilot System, Step 2 (2,000 gpm): Option 2. Influent will consist of 500 gpm, high concentration spring water from LSS-SP-N, with an additional 1,500 gpm from high concentration Hoopes spring water (HS).

Table 5 presents a summary of estimated reductions in concentrations at downstream locations for each treatment scenario.

Table 5. Estimated downstream concentrations (mg/L).

Location	Untreated (Fall 2013)	Pilot, Step 1	Pilot, Step 2 - Option 1	Pilot, Step 2 - Option 2
LSS	0.0194	0.0157	0.0017	0.0017
HS-3	0.0777	0.0715	0.0553	0.0309
LSV-4	0.0414	0.0386	0.0301	0.0182

It is projected that the 1,000 and 2,000 gpm treatment systems have the potential to remove 29 to 60% (respectively) of the selenium in Sage Creek.

Table 1
2013 Flow and Total Selenium Data for HS, HS-3, LSS-SP-N and LSS

Station	Sample Name	Date	Value	Units	Lab	Val	MDL
Flow Rate							
HS	SC0513-HS-SW001-Q	5/20/2013	2.193	cfs			
	SC1113-HS-SW001-Q	11/13/2013	1.7	cfs			
HS-3	SC0513-HS3-SW001-Q	5/20/2013	8.331	cfs			
	SC0813-HS3-SW001-Q	8/23/2013	7.3	cfs			
	SC1113-HS3-SW001-Q	11/14/2013	6.3	cfs			
LSS	SC0213-LSS-SW001-Q	2/25/2013	4.679	cfs			
	SC0313-LSS-SW001-Q	3/27/2013	4.902	cfs			
	SW0413-LSS-SW001-Q	4/25/2013	4.902	cfs			
	SC0513-LSS-SW001-Q	5/20/2013	10.026	cfs			
	SC0613-LSS-SW001-Q	6/27/2013	5.57	cfs			
	SC0813-LSS-SW001-Q	8/23/2013	5.124	cfs			
	SC1113-LSS-SW001-Q	11/13/2013	4.5	cfs			
LSV-4	SC0513-LSV4-SW001-Q	5/19/2013	34.905	cfs			
	SC0813-LSV4-SW001-Q	8/22/2013	17.2	cfs			
	SC1113-LSV4-SW001-Q	11/14/2013	14	cfs			
Selenium, Total							
HS	SC0113-HS-SW001	1/29/2013	0.0897	mg/L			0.001
	SC0213-HS-SW001	2/25/2013	0.0858	mg/L			0.001
	SC0313-HS-SW001	3/27/2013	0.0863	mg/L			0.001
	SW0413-HS-SW001	4/25/2013	0.0937	mg/L			0.001
	SC0513-HS-SW001	5/20/2013	0.0898	mg/L			0.001
	SC0613-HS-SW001	6/27/2013	0.089	mg/L			0.002
	SC0813-HS-SW001	8/23/2013	0.0918	mg/L			0.002
	SC1113-HS-SW001	11/13/2013	0.095	mg/L			0.002
HS-3	SC0513-HS3-SW001	5/20/2013	0.0765	mg/L			0.001
	SC0813-HS3-SW001	8/23/2013	0.0777	mg/L			0.001
	SC1113-HS3-SW001	11/14/2013	0.084	mg/L			0.001
LSS-SP-N	SC0113-LSSSPN-SW001	1/29/2013	0.0776	mg/L			0.001
	SC0213-LSSSPN-SW001	2/25/2013	0.0738	mg/L			0.001
	SC0313-LSSSPN-SW001	3/27/2013	0.072	mg/L			0.001
	SW0413-LSSSPN-SW001	4/25/2013	0.0462	mg/L			0.001
	SC0513-LSSSPN-SW001	5/20/2013	0.069	mg/L			0.001
	SC0613-LSSSPN-SW001	6/27/2013	0.0794	mg/L			0.001
	SC0813-LSSSPN-SW001	9/23/2013	0.0832	mg/L			0.001
	SC1113-LSSSPN-SW001	11/13/2013	0.0821	mg/L			0.001
LSS	SC0113-LSS-SW001	1/29/2013	0.0176	mg/L			0.0004
	SC0213-LSS-SW001	2/25/2013	0.0195	mg/L			0.0004
	SC0313-LSS-SW001	3/27/2013	0.0206	mg/L			0.0004
	SW0413-LSS-SW001	4/25/2013	0.0214	mg/L			0.0004
	SC0513-LSS-SW001	5/20/2013	0.014	mg/L			0.0004
	SC0613-LSS-SW001	6/27/2013	0.0209	mg/L			0.0004
	SC0813-LSS-SW001	8/23/2013	0.0194	mg/L			0.0004
	SC1113-LSS-SW001	11/13/2013	0.0242	mg/L			0.0006
LSV-4	SC0513-LSV4-SW001	5/19/2013	0.0215	mg/L			0.0004
	SC0813-LSV4-SW001	8/22/2013	0.0414	mg/L			0.0008
	SC1113-LSV4-SW001	11/14/2013	0.0507	mg/L			0.001

Table 2 - Selenium Load Removal Estimate - 250 gpm System

Assumptions:

System removes 100% of the Se from the treated water.

Based on the proposed treatment plant location, water treated from LSS-SP-N is discharged upstream of HS-3 (reduced flow at LSS, increased flow at HS-3 post treatment).

Conversion Factors:

453590 mg/lb
3.7854 L/gal
1440 min/day
448.83 cfs/gpm

Step 1, Pilot Study

Treatment Flow Rate: 250 gpm

Before Treatment:

LSS-SP-N Directed to system	Available Flow	125 gpm
	9/23/2013	0.0832 mg/L
	Load:	0.125 lb/day

HS Directed to system	Additional Flow	125 gpm
	8/23/2013	0.0918 mg/L
	Load:	0.138 lb/day

LSS In stream	Flow	5.124 cfs
		2300 gpm
	8/23/2013	0.0194 mg/L
	Load:	0.536 lb/day

HS-3 In stream	Flow	7.3 cfs
		3276 gpm
	8/23/2013	0.0777 mg/L
	Load:	3.06 lb/day

LSV-4 In stream	Flow	17.2 cfs
		7720 gpm
	8/22/2013	0.0414 mg/L
	Load:	3.84 lb/day

Table 2 - Selenium Load Removal Estimate - 250 gpm System

After Treatment:

LSS In stream	Flow	2175 gpm
	Load:	0.411 lb/day
	Concentration:	0.0157 mg/L

HS-3 In stream	Flow	3401 gpm
	Load:	2.92 lb/day
	Concentration:	0.0715 mg/L

LSV-4 In stream	Flow	7720 gpm
	Load:	3.58 lb/day
	Concentration:	0.0386 mg/L

Total Load In Stream:	3.60 lb/day
Total Load Removed By Pilot System:	0.263 lb/day
Percent Reduction:	7%

Equations:

Load:

$$\frac{\text{Concentration} \left(\frac{\text{mg}}{\text{L}} \right) \times 3.7854 \left(\frac{\text{L}}{\text{gal}} \right) \times \text{Flow} \left(\frac{\text{gal}}{\text{min}} \right) \times 1440 \left(\frac{\text{min}}{\text{day}} \right)}{453,590 \left(\frac{\text{mg}}{\text{lbm}} \right)}$$

Percent Reduction:

$$1 - \frac{(\text{Load in stream}) - (\text{Load removed})}{(\text{Load in stream})}$$

Table 3 - Selenium Load Removal Estimate - 1,000 gpm System**Assumptions:**

System removes 100% of the Se from the treated water.

Based on the proposed treatment plant location, water treated from LSS-SP-N is discharged upstream of HS-3 (reduced flow at LSS, increased flow at HS-3 post treatment).

Conversion Factors:

453590 mg/lb
3.7854 L/gal
1440 min/day
448.83 cfs/gpm

Step 2, Option 1 Pilot Study

Treatment Flow Rate: 1000 gpm

LSS-SP-N Directed to system	Available Flow	500 gpm
	9/23/2013	0.0832 mg/L
	Load:	0.500 lb/day

HS Directed to system	Additional Flow	500 gpm
	8/23/2013	0.0918 mg/L
	Load:	0.552 lb/day

LSS In stream	Flow	5.124 cfs
		2300 gpm
	8/23/2013	0.0194 mg/L
	Load:	0.536 lb/day

HS-3 In stream	Flow	7.3 cfs
		3276 gpm
	8/23/2013	0.0777 mg/L
	Load:	3.06 lb/day

LSV-4 In stream	Flow	17.2 cfs
		7720 gpm
	8/22/2013	0.0414 mg/L
	Load:	3.84 lb/day

Table 3 - Selenium Load Removal Estimate - 1,000 gpm System

After Treatment:

LSS In stream	Flow	1800 gpm
	Load:	0.036 lb/day
	Concentration:	0.0017 mg/L

HS-3 In stream	Flow	3776 gpm
	Load:	2.51 lb/day
	Concentration:	0.0553 mg/L

LSV-4 In stream	Flow	7720 gpm
	Load:	2.79 lb/day
	Concentration:	0.0301 mg/L

Total Load In Stream:	3.60 lbm/day
Total Load Removed By Pilot System:	1.05 lbm/day
Percent Reduction:	29%

Equations:

Load:

$$\frac{\text{Concentration} \left(\frac{\text{mg}}{\text{L}} \right) \times 3.7854 \left(\frac{\text{L}}{\text{gal}} \right) \times \text{Flow} \left(\frac{\text{gal}}{\text{min}} \right) \times 1440 \left(\frac{\text{min}}{\text{day}} \right)}{453,590 \left(\frac{\text{mg}}{\text{lbm}} \right)}$$

Percent Reduction:

$$1 - \frac{(\text{Load in stream}) - (\text{Load removed})}{(\text{Load in stream})}$$

Table 4 - Selenium Load Removal Estimate - 2,000 gpm System

Assumptions:

System removes 100% of the Se from the treated water.

Based on the proposed treatment plant location, water treated from LSS-SP-N is discharged upstream of HS-3 (reduced flow at LSS, increased flow at HS-3 post treatment).

Conversion Factors:

453590 mg/lb
3.7854 L/gal
1440 min/day
448.83 cfs/gpm

Step 2, Option 2 Pilot Study

Treatment Flow Rate: 2000 gpm

LSS-SP-N Directed to system	Available Flow	500 gpm
	9/23/2013	0.0832 mg/L
	Load:	0.500 lbm/day

HS Directed to system	Additional Flow	1500 gpm
	8/23/2013	0.0918 mg/L
	Load:	1.655 lbm/day

LSS In stream	Flow	5.124 cfs
		2300 gpm
	8/23/2013	0.0194 mg/L
	Load:	0.536 lbm/day

HS-3 In stream	Flow	7.3 cfs
		3276 gpm
	8/23/2013	0.0777 mg/L
	Load:	3.06 lbm/day

LSV-4 In stream	Flow	17.2 cfs
		7720 gpm
	8/22/2013	0.0414 mg/L
	Load:	3.84 lbm/day

Table 4 - Selenium Load Removal Estimate - 2,000 gpm System

After Treatment:

LSS In stream	Flow	1800 gpm
	Load:	0.036 lb/day
	Concentration:	0.0017 mg/L

HS-3 In stream	Flow	3776 gpm
	Load:	1.40 lb/day
	Concentration:	0.0309 mg/L

LSV-4 In stream	Flow	7720 gpm
	Load:	1.69 lb/day
	Concentration:	0.0182 mg/L

Total Load In Stream:	3.60 lbm/day
Total Load Removed By Pilot System:	2.155 lbm/day
Percent Reduction:	60%

Equations:

Load:

$$\frac{\text{Concentration} \left(\frac{\text{mg}}{\text{L}} \right) \times 3.7854 \left(\frac{\text{L}}{\text{gal}} \right) \times \text{Flow} \left(\frac{\text{gal}}{\text{min}} \right) \times 1440 \left(\frac{\text{min}}{\text{day}} \right)}{453,590 \left(\frac{\text{mg}}{\text{lbm}} \right)}$$

Percent Reduction:

$$1 - \frac{(\text{Load in stream}) - (\text{Load removed})}{(\text{Load in stream})}$$